United States Department of Agriculture

Differences in Replacement Imagery
INFORMATION SHEET
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What is Replacement Imagery?

Replacement imagery, also known as image base replacement in the USDA Farm Service Agency (FSA), takes the place of another imagery dataset covering the same location on the earth's surface. Replacement of imagery may be due to acquisition of imagery that is newer, more spatially accurate or containing more information. It could also be due to a change in FSA program policy.

Why are there differences in replacement imagery from one year to the next?

When new imagery is acquired, it does not match up spatially in every location with past imagery. This can require the line work on vector layers such as Common Land Unit (CLU) or transportation layers to be re-digitized in order to match features on newer imagery. This is the nature of imagery acquisition.

The only way two images could be exactly the same is if imagery was captured from the same exact location above the earth's surface at the same time of the day and same day of the year, from the same camera calibrated in the same manner, during the same atmospheric conditions. Then the image would need to be processed using the same orthorectification process and the same Aerial Triangulation (AT) solution, the same ground control, and the same Digital Elevation Model (DEM). Even then, the two images would likely not look the same.

As with any photography, aerial photography is part art and part science. No two portraits of the same person look exactly the same. Likewise, no two portraits of the earth's surface look the same.

What is Parallax?

Parallax is a distortion caused by an aerial image being shot at an angle, rather than from exactly above a particular point on the ground. More simply, parallax is the apparent shift of an object against a background due to a change in the observer's position, or the apparent motion of an object against a distant background because of a perspective shift.

For example, you are driving and you see an oak tree in a farmer's field. The tree appears to be directly in front of the farmhouse. As you get closer, the tree no longer seems to be in front of the farmhouse, rather in front of the barn. Finally, you drive past the tree and look back. It no longer blocks the farmer's property from view; it now blocks your view of another farmer's land you passed a mile back.

This same phenomenon occurs with aerial photography, and more so with tall objects such as trees or buildings. One year the tall oak tree blocks the farmhouse on the imagery, while the next year it blocks part of the field, which could lead someone to make the assessment that useable acreage for farming had decreased. This could result in edits to the CLU.

What is Sun Angle?

The angle of the sun is a direct result of latitude, time of day, and year. The sun angle causes shadows to be cast from things at a higher elevation onto things at a lower elevation. When shadows are cast, it can be difficult to discern what is in the shadow. The area within a shadow is an area where less data is acquired; little light is reflected from within shadows.

Shadows can help identify things, but can also be detrimental. Shadows cast by large trees, clouds, buildings, mountains, hills, tops of canyons, etc., can hide data that may be required for decision making.

For example, one year the sun was almost overhead, and the trees next to a CLU cast almost no shadow. The next year the sun was a bit lower in the sky, and the trees seem to have enlarged in size, seemingly reducing the acreage of the CLU, and making CLU line work look less than perfect. If the shadow is interpreted as part of the tree and not recognized as a shadow in an image, a change to CLU might be edited with a subsequent incorrect determination of acreage.

What is a Digital Elevation Model (DEM)?

DEMs are digital files consisting of optimal arrays of point elevations, sampled at equally spaced intervals. DEMs are used to simulate elevations when creating digital orthorectified photo products, or for numerous other purposes when analysis of elevation is important.

The accuracy of DEM data depends on the source and resolution of the data samples. DEM accuracy is derived by comparing interpolated elevations in the DEM with map location elevations. Then a root-mean-square error (RMSE) can be computed. RMSE is a measure of how closely a data set matches the represented real world elevations.

For many years the National Elevation Dataset (NED) was the standard used for NAIP and many other imagery projects. The NED elevation data and efforts are now part of the 3D Elevation Program (3DEP). The NED data is still available and is being updated, ideally using light detection and ranging (lidar) methods. There are many different DEMs available. All of these DEMs vary in number of points and accuracy. Unless exactly the same DEM is used, there will be differences in the resulting aerial photography product.

Additional info:
The NED branding is being retired, and beginning in 2015 these seamless layers are now being offered as part of the 3DEP product suite.
https://nationalmap.gov/3DEP/3dep_prodnews.html

NED data are still available and being updated continually, but the 'NED' terminology has been retired. The national DEM layers previously referred to as the 'NED' are now branded as 3DEP seamless DEMs. These seamless national DEM layers are just a few of the datasets offered in the broader suite of 3DEP elevation products. For a description of 3DEP products and services, visit
http://nationalmap.gov/3DEP/3dep_prodserv.html.
https://www2.usgs.gov/faq/categories/9865/7802%20

What is orthorectification?

Orthorectification is the term for the process of removing sources of distortion from an image and correcting aerial photography to the point where measurements of a feature on the photograph approximate ground measurements of the same feature.

Without orthorectification, one would not be able to make measurements of distances, positions, or areas from aerial photography. Orthorectification tries to remove distortions created by the 3 dimensional nature of the earth projected into a 2 dimensional surface.

Terrain distortion can be reduced by rectifying imagery using a DEM and control points. The DEM is used to note mathematical relationships between real world topography and the aerial image. These relationships are defined, and displacement inherent in the image reduced, by warping the image so that distance and area are uniform in relation to the real world.

What is Aerial Triangulation (AT) and control configuration?

Aerial Triangulation is an attempt to identify the exact x, y, z, location of an aircraft antenna during exposure. Ground control points are used to triangulate signals from the aircraft and help identify this exact location. Factoring into AT is the specific location/distribution of the control points. Generally, with the use of more control points, located closer to the aircraft, the location identification will be more accurate. The closer to the real x, y, z, location the AT calculations are, the more accurate the resulting image can be to the true ground location.

There are other methods of pinpointing the exact location of an aircraft; airborne GPS and Internal Navigation System (INS) to name a few. Depending on the AT solution and control point configuration, various levels of known point accuracy will result. If methods and resulting accuracies differ from year to year, imagery will look slightly different from one year to the next.

What is the difference between absolute and relative accuracy?

Horizontal and vertical accuracy of an image when compared to another image is considered relative accuracy. The two images could be a hundred miles from where they actually reside on the earth's surface, and still be accurate relative to each other.

With absolute accuracy, an image is not compared to another image, but rather to where the data on the image really exists on the earth's surface, usually based on a network of control points, usually measured with a Global Positioning System (GPS) device.

APFO used relative accuracy for NAIP until 2005, comparing new imagery to older base imagery. From 2006-2008, nine states were selected to meet the absolute accuracy specification: Utah in 2006, Arizona in 2007, and Indiana, Minnesota, New Hampshire, North Carolina, Texas, Vermont, and Virginia in 2008. Beginning in 2009, all states flown adhered to this specification.

What does all this mean to the farmer?

Drawing CLU based on imagery is not an exact science. Acreage measurements may change slightly when newer imagery is used. However, acreage should not change drastically due to replacement imagery, unless there was an actual change of land use on the earth's surface, such as a new road cut or building on cropland.

Measurements taken from imagery can be extremely accurate and a huge time saver; however, the *most* accurate measurement of acreage still relies on field surveys and GPS.

Who do I contact for more information?

1. For sales information, contact USDA-FSA-APFO at 2222 W 2300 S, Salt Lake City UT, 84119-2020, call 801-844-2922, or visit http://www.apfo.usda.gov/.

2. If you have general questions about replacement Imagery, contact GIS Specialists Joan Biediger 801-844-2951, Zack Adkins 801-844-2925, David Davis 801-844-2933 or Louise Mathews 801-844-2934.